Problem Statement

In order to help infants and small children with swallowing disorders prevent aspiration during swallowing of a liquid, a cup or bottle will be designed with an accurate adjustable volume-dispensing mechanism so the child may receive a constant bolus size with every swallow. The device will be easily cleaned, microwave-safe, and aesthetically pleasing.

Background Information

A major problem that an individual with a swallowing disorder faces is the risk of aspiration, the flow of fluid into the respiratory airways instead of through the esophagus. When a person with improper swallowing techniques swallows a bolus of liquid, the movement of the bolus depends mainly on gravity. If the bolus sits as residue near the back of the mouth, it could easily move into the trachea during the next breath that the person takes (Robbins, 2000). As the bolus volume increases during swallowing, the chance for aspiration increases because it becomes more likely that some of the bolus would enter the trachea. For young children, the probability of aspiration increases because the child might try to swallow too much liquid at one time (Matzdorf, 2001).

There are several volume-limiting technologies that already exist on the market; however none completely meet the client's design requirements. The Adjustable Volume Dispenser by Bodi Company, Inc (Figure 1), a plastic bottle that changes the volume using a pressure mechanism, only delivers the liquid in 5 cc increments, and the client would like increments of 1 cc for her device.

Figure 1. Adjustable Volume Dispenser by Bodi Company, Inc.

On the other hand, the Seripettor by BrandTech Scientific, Inc. (Figure 2), a bottletop dispenser used in scientific laboratories, delivers fluid in increments less than 1 cc, but it is designed to attach to a large glass bottle. This setup would not be conducive for feeding an infant or small child because the fluid volume would have to be dispensed into a separate container, which leads to extra work for the parent if this device were to be used for infants or small children.

Figure 2. The Seripettor by BrandTech Scientific, Inc.

A third existing product is the “Limited Flow” Drinking Cup by Reliant Medical Products, Inc. (Figure 3). This design allows a set volume of liquid to be delivered to the user; however, the volume per swallow is fixed and constant, which does not meet our client’s needs for an adjustable volume.

Figure 3. “Limited Flow” Drinking Cup by Reliant Medical Products, Inc.

Information Obtained

Our team will work to improve swallowing control by limiting the volume of fluid per bolus swallowed. The specifications for our device are as follows: The volume delivered for single swallow should be between one and five cubic centimeters, and the maximum volume capacity should be 240 cubic centimeters. The measurable increments between markings on the device should be no more than 5 cubic centimeters. The device must be easily cleaned, preferably in the dishwasher. It should be adaptable for infants as well as teenagers. The device should cost between $13.00 and $15.00. However, cost may exceed this range if the device works very well. Metal and allergenic materials should be avoided so that the device can be used in the microwave. The device should have two handles and nice aesthetics on the outside.

In the future, we will need to obtain information about microwaveable materials, namely plastics, including both the cost and availability of these materials. Also, information on how to calibrate the volume of the device will be necessary to determine the accuracy of the volume measurements.

Alternative Designs

Our prototype is a mechanical drinking device that will limit the amount of fluid that comes out when a patient takes a sip. There are three designs that we came up with: the Shot Top, the Pump Cup, and the Screwdriver. All three have very different mechanisms involved in the separation of the fluid reservoir and the sipping chamber, which has a measured volume.

The Shot Top uses the mechanism involved in measuring shots at a bar (Figure 4). A bartender puts a special top on a liquor bottle. The top has a ball in it, so when it is tipped upside down liquor pours out until the ball stops the hole where the liquid comes out. We decided to make this mechanism larger, so instead of it fitting over a bottle, it fit over an entire cup. The devices used in bars only allow for one increment (shot increments). Our design allows for many different increments by allowing the patient to manipulate the placement of the ball. As the distance between the ball and the sipping chamber increases, the volume of liquid delivered to the user increases.

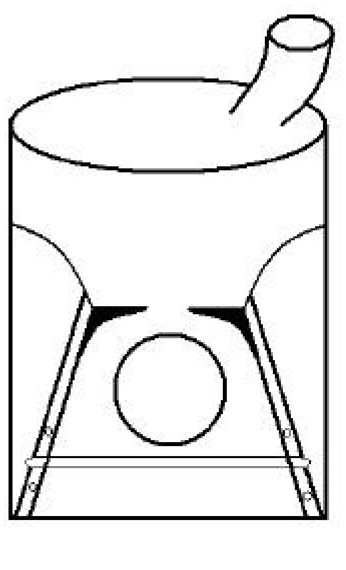

Figure 4. The Shot Top.

A major drawback to this design is that it would be difficult to make accurate measurements using this mechanism. The ball might never fully plug up the hole unless an extremely tight fit was accomplished in every pour.

The second design that we created is called the Pump Cup (Figure 5). The Pump Cup uses air pressure to separate the sipping chamber from the fluid reservoir. In this design, the patient determines how much liquid should be swallowed by pumping the cup a certain number of times. Every time the pump is pressed, pressure is exerted into the fluid reservoir. As a result, the liquid is pushed through a tube into the sipping chamber. One- way valves are needed along this tube to prevent backflow.

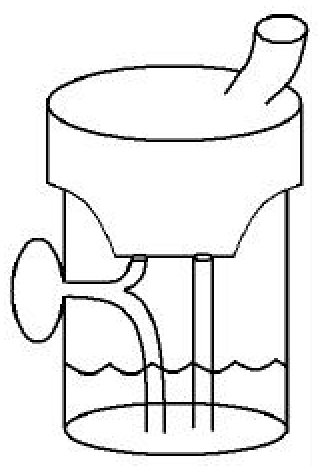

Figure 5. The Pump Cup.

There are two drawbacks to this design. First, there are too many small pieces, such as narrow tubes, and one-way valves. This means that the device would be too hard to clean, and/or it is easily breakable. Also, it would be hard to match up pumps to a standard measure of volume increments. To design and build a pump that pushes an exact number of cubic centimeter increments would be too time consuming.

Our third design, the screwdriver, is our favored design (Figure 6). An adjustable divider separating the sipping chamber and the fluid reservoir can be moved vertically to change the volume delivered. The entire inside of the cylindrical cup is lined with thread (like on a screw). The divider also has 2-3 threads so it can rotate within the cup. There is a hole in the divider to allow the liquid to fill both compartments. A tab can rotate around a small cylinder to cover the hold when the cup is inverted. The user can either drink directly from the spout on the cover or from the rubber nipple top from an infant bottle.

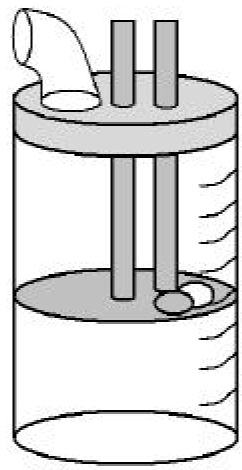

Figure 6. The screwdriver design.

The screwdriver is our proposed solution because the parts can be disassembled for easy cleaning. It could be used by a person of any age, ranging from infant to adult. The design is fairly simple so that any person could understand how to use it with a few directions. Also, all of the pieces are large enough that they would not be potential choking hazards.

A potential problem with this design would be the process of building it. A specialized machine would have to be used to make the threads on the inside of the cup and on the divider. It is unknown whether we have access to the equipment that would be necessary to construct the prototype of this design. Hopefully, we will be able to find the necessary equipment. Also, calibration of the volume markings on the sides of the cup could be difficult. A small percentage of the accuracy might have to be sacrificed in the calibration process.

Overall, however, we are confident in the screwdriver design and believe it is the best solution for the client's proposed project since it satisfies her requirements and constraints.

References

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